process, and this phenomenon, moreover, is of such magnitude in the polar regions that it tends to stabilize the seasonal fluctuations."

It is clear from the small ratio of icebergs to total ice, that the discharge of glacial ice is of no practical moment in the cooling of sea water. Further, the fact that in vertical dimension, total sea ice is only about one-thousandth of the mean depth of the Atlantic shows how superficial the ice processes must be. Melting produces relatively light thaw water, which stratifies stably at the surface and creates a situation in which solar warming of the summer season is largely accumulated as a heat reserve in the upper layer of only 20 to 40 meters depth, underlaid by a tremendous mass of cold water representing the net accumulations from winter cooling by radiation, within the great area of the Polar Basin and its adjacent waters.

The radiation absorbed in the areas of open water, which is thus largely confined to the shallow top layer, is readily lost, with the onset of winter, and is not adequately compensated by the latent heat released by freezing of new ice. These and other considerations lead to a quantitative estimate that only about 10 per cent of the total cooling received by the North Atlantic in the southward discharge of cold currents can be attributed to the cooling effect of ice melting. The final summations are best stated in the author's own words, as follows:

> Obviously, the low temperature character of the Labrador and east Greenland currents is not due to the melting ice with which these streams are charged in spring and summer. These ocean currents are cold because of the small amount of absorption of solar radiation at the earth's surface in the polar regions. * * *
>
> It is interesting to note in the quantitative treatment of these northern seas phenomena that the cooling factors, viz, chilling by the winter atmosphere, ice melting, snowfall, and evaporation, when totaled, outweigh the solar warming of summer. * * * The great major effect therefore tending to maintain more or less of a constant counterbalance over a long period is the warm currents from the Tropics. * * *
>
> Perhaps it is because the ice catches the eye and the imagination more than do the coastal water masses with which it is ordinarily associated that its relative importance in the picture of oceanographic circulation has been overemphasized. The regional difference of density between coastal and oceanic waters is the main spring for the convectional currents. The winds also, by their direct frictional effect, combined with the presence of the coast lines or other hindrances, develop significant slope currents. The transition zones, i. e., the continental edges, and the (submarine) ridges, mark the belts of greatest energy, and in the sea energy is synonomous with current.
>
> Ice melting over the North American and east Greenland shelves helps to accentuate the contrasts between coastal and oceanic waters, thereby intensifying the currents, but emphatically it is not the main cause of propulsion nor is it even a necessary attribute thereof.

The bulletin is amply illustrated with diagrams, charts, and pictures but the lack of a good map of the north polar regions, fully identifying the geographic features to which frequent and repeated reference is made, is the one point of inadequacy found in this interesting and valuable contribution to oceanography.

CLOUD FLIGHTS [1]

By A. LOHR

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[Translated by Eric R. Miller and abstracted by L. T. Samuels]

The daily airplane observation flights made by the Deutsche Seewarte at the Fuhlsbüttel airport have been classified and those made at times when the airplane passed through a solid cloud layer, i. e., when during both the ascent and the descent the earth was entirely cut off from view, have been segregated. The percentages of such flights of the total during 1928 and 1929 were 46 and 44, respectively.

The following features are mentioned:

If the lower boundary of a solid cloud sheet consists of Fr. St. or Fr. Nb., then there is no great danger in emerging from the cloud in descent as the turbulence existing near the ground, indicated by the Fr. St. and Fr. Nb., results in the partial dissipation of the lower boundary of low cloud forms. The Fr. St. or Fr. Nb. very frequently extends to within 100 meters of the ground and has a vertical thickness of 100 to 300 meters. With Nb. there follows immediately the transition to the continuous main cloud sheet, whereas with St. there is often observed a separate thick, clear, intermediate stratum between the Fr. St. and the dense continuous St. A far more dangerous condition to aviation occurs when the Fr. St. or Fr. Nb., stratum is absent and the base of the main cloud sheet is only 100 to 150 meters above ground. In such cases the cloud layer may often reach the ground in some places.

The form of the upper surface of the cloud sheet is varied. On many days it appears like an entirely plane surface. At such times a strong temperature inversion always exists at its level. When a heavy accumulation of haze prevails over the upper cloud surface, then from a greater height the cloud layer appears as an absolutely smooth surface. Occasionally the upper surface is slightly rippled and shows an irregular structure, while at other times it is regularly waved. The wave crests may extend lengthwise for a kilometer but are never very high. All of the types of clouds thus far referred to are an indication of little or no vertical motion within the layer.

Turbulence rolls such as occur in a St. Cu. layer are fundamentally different from the above-mentioned wave structure. In summer, it frequently happens that a horizontal upper surface is overtopped by single Cu. heads which indicate local and narrowly limited overheating. Such Cu. forms are frequently surrounded by cloud-free holes in which descending air creates rather strong "falling" bumpiness.

The cumuli of convection exhibit a more stupendous form than the cumuli of turbulence. The former rise most steeply into the heavens and when illuminated by the sun conjure up marvelous pictures by their rugged lights and shadows. From them, occasionally, thunderheads rise upward to 6,000 meters altitude. The strong bumpiness around the edge of such thunderheads is well known. Flying through them can not be sufficiently warned against. Within such clouds vertical gusts reaching from 10 to 15 meters per second are encountered, while below an ordinary cumulus these velocities usually reach only 2 to 4 meters per second, the latter being very successfully employed in early gliding experiments.

In connection with the vertical currents in upwelling Cu. heads there occur the "caps" over the Cu., the latter being composed mostly of ice particles. Often the raised St. layers that are penetrated by the thunderhead spread

[1] Meteorologische Zeitschrift, September, 1930.

out at the flank of the towering head and may rise upward over the latter. At times the veil-like St. may be elevated throughout an extensive region by the underlying turbulent stratum so that it has the appearance from a greater height of a smooth stratus sheet in which the Cu. are embedded as soft fountain-like forms.

In airplane observations it is often necessary to penetrate a uniformly dense, formless cloud mass more than 4,000 meters thick, when frequently it is impossible to see the tips of the wings of the airplane. An extreme case of this kind occurred on January 2, 1930, when upon descending, the airplane entered the cloud at 5,000 meters elevation and emerged from it at about 50 meters above the ground. Such enormous cloud formations appear nearly always to be associated with the passage of a "wind convergence."

During one flight to 7,000 meters elevation, an opportunity was afforded to observe Ci. at close range. The impression obtained was that massive fall-stripes (Fallstreifen) are formed from Ci. clouds and that they (Ci.) are composed of ice crystals.

During a night flight in the autumn of 1928 the gleam of light from the city appeared on the cloud surface with great clearness.

It was occasionally found that the starting of the airplane motor caused the "ripping open of a lane" in a ground fog.

In Cu. of turbulence it was found that the rows ran mostly in long streaks some hundreds of meters apart, parallel to one another, nearly in the direction of the wind. These rows often exhibited cross-rippling.

Although flights within or under the "squall roll" are to be avoided, some flights were started shortly before an oncoming squall. It was found that over a breadth of 3 to 5 kilometers in front of the "squall roll" there exists a strong vertical bumpiness, which disappears, however, directly above the "squall roll." The area behind the "squall head" is, likewise, free from bumpiness.

It was found to be very difficult to estimate correctly the height of clouds from the ground and to judge their vertical extent from their appearance. In a uniform stratus layer, the visibility horizontally and vertically downward sometimes vanishes immediately on entering the cloud, while at other times the ground is visible for a long time through the cloud mass. This may be due to the size and number of the cloud droplets. From a study of fog, being made at the Deutsche Seewarte, it has been found that fog droplets may be regarded as smooth, opaque little disks and, therefore the visibility varies according to the number and radius of the droplets, with the same vapor content of the air.[2]

[2] A drop of any given radius is equivalent in mass to 8 drops of half that radius, while its equatorial cross section is half the sum of the similar cross sections of the 8 small drops. Hence the interference of the 1 large drop, to a beam of light is just half that of the equivalent 8, except in so far as 2 or more of the latter may chance to be along the same line of sight. Clearly then, for any given mass of water in droplet form (fog or cloud) betweeen observer and object, the visibility increases roughly as the radius of the droplets.—Ed.

SHOWER AND DRIZZLE

By W. J. Humphreys

Of course everyone knows what a shower is and what a drizzle is too, until he tries to define them. For our present purpose, which is to consider how each is produced, and what therefore under given circumstances it probably signifies, we shall define a shower as a rain of brief duration of medium-sized to large drops; and a drizzle as a very light rain, usually more or less persistent, of quite small drops. If the drops are as much as one twenty-fifth of an inch in diameter, or larger, surely they do not constitute a drizzle, but rain, and fall with a velocity of, roughly, 10 to 25 feet per second, as determined by the size of the drop and density of the air through which they are falling. They can not fall faster than around 25 feet per second because if, and as soon as, through coalescence or otherwise, they become large enough to fall with a greater speed they at once are torn to pieces by the drag of the air through which they are passing. But the rate of fall, whatever it be, is of course, with reference to the air and therefore not at all necessarily the speed of approach toward the surface of the earth. The two velocities, that is, the rate of fall through the air and the rate of approach toward the surface of the earth, are the same only when there is no vertical movement of the air through which the drops are falling. Wherever, then, the upbrush of the air is equal to, or greater than, the rate of fall of the drops through such atmosphere, that particular precipitation can not approach closer to, much less reach, the surface. Of course the greater the height and, consequently, the rarer the air, the greater its upward velocity must be, and in proportion to the decrease of density, to sustain drops of a given size.

Only the largest possible raindrop, one fifth of an inch in diameter, falls through still air of average sea level density at the uniform rate of 25 feet per second. The drops of a moderate rain, as that term is commonly used, having a diameter of, roughly, one twenty-fifth of an inch, have a velocity of fall of about 12 feet per second. Drizzle drops, so small that it would take about 125 of them to span an inch, fall only some two and a quarter feet per second, while cloud droplets, 1,200 of which would stretch barely one inch, fall only one twenty-fifth of a foot, or thereabouts, per second, or 144 feet in the course of an hour.

From the foregoing it is clear that for each given velocity of ascent of the air there is a corresponding minimum size of raindrop that can get through it to lower levels. Smaller drops can not fall while the appreciably larger ones must and do. Hence ascending air carries cloud droplets up and keeps them up until by further condensation, coalescence, or both together, they have grown large enough to overcome the lift of the rising air, whereupon, but *not* until they have so grown, they fall to the earth.

If appreciably rising air carries cloud droplets up, as it certainly does, one asks then how it is that the cloud itself, base and all, is not lifted to greater heights. The explanation is that while the individual droplets are lifted to greater levels fresh cloud is continuously formed in the uprising air as soon as, through expansion, incident to increase of height, it has cooled to its dew point, or saturation temperature. The individual particles are carried up, but continuously replaced by freshly-formed droplets at the same cloudbase level. And if the ascent is gentle the droplets soon are evaporated a little way above in the drier air and no rain is formed.

A drizzle, then, or very gentle rain of quite small drops, occurs only where there is little or no ascent of the air—two and a half feet per second at most. A shower, on the other hand, which consists of relatively large drops, requires for its production vertical convection of consider-